APPENDIX G

DEFINITIONS OF INNOVATIVE TECHNOLOGIES

SELECTED FOR NPL SITE CLEANUPS

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Soil Control Technologies

***Ex Situ* Bioremediation**	This technology uses microorganisms to degrade organic contaminants in excavated soil, sludge, and solids. The microorganisms break down the contaminants by using them as a food source. The end products are typically CO_2 and H_2O. *Ex situ* bioremediation includes slurry-phase bioremediation, in which the soils are mixed in water to form a slurry, and solid-phase bioremediation, in which the soils are placed in an cell or building and tilled with added water and nutrients. Land farming and composting are types of solid-phase bioremediation.
***In Situ* Soil Bioremediation**	With *in situ* bioremediation, an oxygen source and, sometimes, nutrients, are pumped under pressure into the soil through wells, or they are spread on the surface for infiltration to the contaminated material. Bioventing is a common form of *in situ* bioremediation. Bioventing uses extraction wells to circulated air with or without pumping air into the ground.
Contained Recovery of Oily Wastes (CROW™)	This process displaces oily wastes with steam and hot water. The contaminated oils are swept into a more permeable area and are pumped out of the soil.
Cyanide Oxidation	Organic cyanides are oxidized to form less hazardous compounds though chemical reactions.
Dechlorination	Dechlorination is a chemical reaction which removes or replaces chlorine atoms contained in hazardous compounds, rendering them less hazardous.
Hot Air Injection	With hot air injection, heated air is injected and circulated through the subsurface. The heated air volatizes volatile organic compounds so they can be extracted and captured for further treatment or recycling.
***In Situ* Flushing**	For *in situ* flushing, large volumes of water at times supplemented with treatment compounds, are introduced to the soil, waste, or groundwater to flush hazardous contaminants from a site. Injected water must be isolated effectively within the aquifer and recovered.
Physical Separation	Removes contaminants from a medium in order to reduce the volume of material requiring treatment.
Phytoremediation	Phytoremediation involves the cultivation of specialized plants that are capable of taking up specific soil contaminants into their roots or foliage. Uptake of contaminants by the plants reduces concentrations of contaminants in the soil. Periodic harvesting of the plants may be necessary.

Plasma High Temperature Metals Recovery This technology is a thermal treatment process that purges contaminants from solids and soils as metal fumes and organic vapors. The organic vapors can be burned as fuel and the metal fumes can be recovered and recycled.

Soil Vapor Extraction (SVE) This technology removes volatile organic compounds from the soil through the use of vapor extraction wells, sometimes combined with air injection wells, to strip and flush the contaminants into the air stream for further treatment.

Soil Washing Soil washing is used for two purposes. First, the mechanical action and water (sometimes with additives) physically remove the contaminants from the soil particles. Second, the agitation of the soil particles allows the more highly contaminated fine particles to separate from the larger ones, thus reducing the volume of material requiring treatment.

Solvent Extraction Solvent extraction operates on the principle that, in the correct solvent, organic contaminants can be solubilized preferentially and removed from the waste. The solvent to be used will vary, depending on the waste type.

Thermal Desorption For thermal desorption, the waste is heated in a controlled environment to cause organic compounds to volatilize from the waste. The operating temperature for thermal desorption is less than 1000°F (550°C). The volatilized contaminants will usually require further control or treatment.

Vitrification Vitrification melts contaminated soil in place at temperatures of approximately 3000°F (1600°C). Metals are encapsulated in the glass-like structure of the melted silicate compounds. Organics may be treated by combustion.

Groundwater Treatment Technologies

Air Sparging Air sparging involves injecting air or oxygen into the aquifer to strip or flush volatile contaminants as the air bubbles up through the groundwater and is captured by a vapor extraction system. The entire system acts as an *in situ* air stripper. Stripped or volatized contaminants usually will be removed through soil vapor extraction wells and usually require further treatment.

***In Situ* Groundwater Bioremediation** With *in situ* bioremediation, which is often combined with air sparging, nutrients or an oxygen source (such as air) are pumped under pressure into the aquifer through wells to enhance biodegradation of contaminants in the groundwater.

Dual-Phase Extraction

Dual-phase extraction removes contaminants simultaneously from both the saturated and the unsaturated zone soils *in situ*. This new technology applies soil vapor extraction techniques to contaminants trapped in saturated zone soils, which are more difficult to treat than are those in the unsaturated zone. In some instances, this result may be achieved by sparging the groundwater section of a well that penetrates the groundwater table. Other methods also may be employed.

***In Situ* Oxidation**

This technology oxidizes contaminants that are dissolved in groundwater, converting them into insoluble compounds.

Passive or Permeable Treatment Walls

Passive treatment walls act like chemical treatment zones. Contaminated groundwater comes into contact with the wall, which is permeable, and a chemical reaction takes place. Limestone treatment zones increase the pH, which effectively immobilizes dissolved metals in the saturated zone. Another type of passive treatment wall contains iron filings that dechlorinate compounds.

Surfactant Flushing

Surfactant flushing of non-aqueous phase liquids (NAPL) increases the solubility and mobility of the contaminants in water, so that the NAPL can be biodegraded more easily in the aquifer or recovered for treatment aboveground via a pump-and-treat system.